Grass Carp (*Ctenopharyngodon idella*)
Ecological Risk Screening Summary

Web Version—08/11/2014

Photo (edited): U.S. Fish and Wildlife Service

1 Native Range, and Status in the United States

Native Range
From Shireman and Smith (1983):

"Asia: China to eastern Siberia (Amur River system, Berg 1964)."

Status in the United States

From Nico et al. (2014):

"Grass carp have been recorded from 45 states; there are no reports of introductions in Alaska, Maine, Montana, Rhode Island, and Vermont. It is known to have established populations in a number of states in the Mississippi River basin. Breeding populations have been recorded for the Mississippi River in Kentucky (Conner et al. 1980, Burr and Warren 1986), the Illinois and upper Mississippi rivers of Illinois and Missouri (Raibley et al. 1995), the lower Missouri River in Missouri (Raibley et al. 1995), the Mississippi River or its tributaries in the states of Arkansas (Conner et al. 1980), Louisiana (Conner et al. 1980, Zimpfer et al. 1987), Tennessee (Etnier and Starnes 1993), and presumably Mississippi (Courtenay et al. 1991). It is also established in the Ohio River in Illinois (Burr, personal communication); it was listed as established in Minnesota (Courtenay et al. 1991, but see Courtenay 1993), and in the Trinity River of Texas (Waldrip 1992, Webb et al. 1994, Elder and Murphy 1997). Courtenay (1993) listed grass carp as established in eight states, Arkansas, Kentucky, Illinois, Louisiana, Missouri, Mississippi, Tennessee, and Texas; an additional one, Minnesota, was included in an earlier listing of states with established populations (Courtenay et al. 1991). Stone (1995) listed this species as being established in Wyoming; however, Stone (personal communication) clarified his earlier report by stating that, as of early 1997, there is no evidence of natural reproduction in that state. Similar to a few other authors, he used the term 'established' to indicate that grass carp populations have persisted for many years, presumably because of their long life span and because of long-term maintenance of wild populations through continued stockings. Pearson and Krumholz (1984) mentioned several records from the Ohio River, including river mile 963 on the Illinois-Kentucky border and from the Falls of the Ohio, at Louisville, along the Kentucky-Ohio border. They also stated that the species had been stocked in many private ponds and lakes in the Ohio River basin. Sigler and Sigler (1996) stated that this species is no longer found in Utah, but they provide no details. Harvest of grass carp by commercial fishermen in the Missouri and Mississippi rivers of Missouri has exhibited a general climb. In 1996, the most recent available data, there was a record reported harvest, about 44,000 pounds, 8 percent of the total commercial fish harvest (J. W. Robinson, personal communication). Starnes et al. (2011) report grass carp as stocked and occassionally occurring in the lower Potomac River and C&O Canal near Plummers Island."

"Grass carp have been recorded from Alabama (Guillory and Gasaway 1978, Boschung 1992, Kirk et al. 1994, Mettee et al. 1996, Rasmussen 1998, Bain [et al.] 1990, Tucker 1979, Clugston 1990, Etnier, pers. comm., Chapman, pers. comm.); Arkansas (Buchanan 1973, Guillory and Gasaway 1978, Conner et al. 1980, Zimpfer et al. 1987, Clugston 1990, Mississippi Museum of Natural Science 2004); Arizona (Minckley 1973, Guillory and Gasaway 1978, Lee et al.1980 et seq., Courtenay et al. 1984, 1991); California (Guillory and Gasaway 1978, Lee et al.1980 et seq., Courtenay et al. 1984, 1991, Dill and Cordone 1997, Thiery 1990); Colorado (Guillory and Gasaway 1978, Courtenay et al. 1984, 1991, Woodling 1985, Rasmussen 1998); Connecticut (Whitworth 1996); Delaware (Courtenay et al. 1984, 1991, Raasch and Altemus 1991, Rohde et al. 1994); Florida (Guillory and Gasaway 1978, Lee et al.1980 et seq., Courtenay et al. 1984, Florida Game and Freshwater Fish Commission 1989, 1994, Burkhead and Williams 1991, Shafland 1996, Tseng 2002, Hill and Cichra 2005, Nico 2005, Charlotte Harbor NEP 2004, Colle et al 1989); Georgia (Guillory and Gasaway 1978, Lee et al.1980 et seq., Courtenay et al. 1984, Burkhead et al. 1997, Walters 1997); Hawaii (Maciolek 1984); Idaho (Courtenay et al. 1984, 1991, Idaho Fish and Game 1990); Illinois (Pflieger 1975, Anonymous 1977, Guillory and Gasaway 1978, Smith 1979, Lee et al.1980 et seq., Phillips et al. 1982, Burr and Page 1986, Burr et al. 1996, Laird and Page 1996, Raibley 1995, Blodgett 1993, Rasmussen 1998, Illinois Natural History Survey 2004); Indiana (Anonymous 1977, Guillory and Gasaway 1978, Lee et al.1980 et seq., Simon et al. 1992, Tilmant 1999); Iowa (Guillory and Gasaway 1978, Burr and Page 1986, Harlan et al. 1987, Courtenay et al. 1991, Young et al. 1997, Hatch and Schmidt 2002); Kansas (Guillory and Gasaway 1978, Courtenay and Williams 1992, Cross and Collins 1995, Rasmussen 1998); Kentucky (Lee et al.1980 et seq., Conner et al. 1980, Courtenay et al. 1984, 1991, Burr and Page 1986, Burr and Warren 1986, Etnier personal communication); Louisiana (Guillory and Gasaway 1978, Conner et al. 1980, Conner and Suttkus 1986, Zimpfer et al. 1987, Carp Task Force 1989, Rasmussen 1998); Maryland (Guillory and Gasaway 1978, Courtenay et al. 1984, 1991, Rohde et al. 1994, Starnes et al. 2011); Massachusetts (Courtenay et al. 1984, 1991, Hartel 1992, Hartel et al. 1996, USFWS 2005); Michigan (Guillory and Gasaway 1978, Lee et al. 1980 et seq., Courtenay et al. 1984, Emery 1985, Cudmore-Vokey and Crossman 2000); Minnesota (Phillips et al. 1982, Courtenay et al. 1984, 1991, Hatch and Schmidt 2002, [Raibley et al.] 1995); Mississippi (Guillory and Gasaway 1978, Courtenay et al. 1991, Courtenay 1993, Ross 2001, Schramm and Basler 2004); Missouri (Pflieger 1975, 1978, 1997, Guillory and Gasaway 1978, Brown and Coon 1991, Young et al. 1997, Rasmussen 1998, Raibley 1995, Mississippi Museum of Natural Science 2004, Etnier personal communication); Nebraska (Guillory and Gasaway 1978, Courtenay et al. 1984, 1991, Rasmussen 1998, USFWS 2005, Nebraska Parks and Game Commission, unpublished); Nevada (Courtenay et al. 1984, 1991, Deacon and Williams 1984, Vinyard 2001); New Hampshire (Guillory and Gasaway 1978, Lee et al. 1980 et seq., Schmidt 1986); New Jersey (Guillory and Gasaway 1978, D. Mitchell and Soldwedel, personal communication); New Mexico (Guillory and Gasaway 1978, Courtenay et al. 1984, 1991, Cowley and Sublette 1987, Sublette et al. 1990); New York (Guillory and Gasaway 1978, Courtenay et al. 1984, 1991, Smith 1985, Schmidt 1986, Cudmore-Vokey and Crossman 2000, J. Freidhoff, pers. comm., W. Stone, pers. comm.); North Carolina (Guillory and Gasaway 1978, Lee et al. 1980 et seq., Courtenay et al. 1984, 1991, Menhinick 1991, Rohde et al. 1994, Beshears 2004, 2005); North Dakota (Lee et al. 1980 et seq., Owen et al. 1981, Power and Ryckman 1998, Rasmussen 1998); Ohio (Guillory and Gasaway 1978, Lee et al. 1980 et seq., Courtenay et al. 1984, 1991); Oklahoma (Guillory and Gasaway 1978, Lee et al. 1980 et seq., Courtenay et al. 1984, Cashner and Matthews 1988, Pigg et al. 1992, Rasmussen 1998, USFWS 2005); Oregon (Lee et al. 1980 et seq., Pauley et al. 1994, Kulla 2004); Pennsylvania (C. N. Shiffer, personal communication); South Carolina (Guillory and Gasaway 1978, Lee et al. 1980 et seq., Courtenay et al. 1984, 1991, Foltz and Kirk 1994, Rohde et al. 1994); South Dakota (Guillory and Gasaway 1978, Lee et al. 1980 et seq., Owen et al. 1981, Young et al. 1997); Tennessee (Guillory and Gasaway 1978, Ryon and Loar 1988, Etnier and Starnes 1993); Texas (Guillory and Gasaway 1978, Lee et al. 1980 et seq., Conner and Suttkus 1986, Trimm et al. 1989, Howells 1992, Howells 1993, Howells 1999, Red River Authority of Texas 2001, Texas Parks and Wildlife Department 2001, Yoon 2003, Anonymous 1994, Waldrip 1992); Utah (Courtenay et al. 1984, 1991, Sigler and Sigler 1996); Virginia (Guillory and Gasaway 1978, Lee et al. 1980 et seq., Courtenay et al. 1984, 1991, Jenkins and Burkhead 1994, Rohde et al. 1994); Washington (Pauley et al. 1994, Fletcher, personal communication, Roesler 2003); West Virginia (Guillory and Gasaway 1978, Lee et al. 1980 et seq., Courtenay et al. 1991); Wisconsin (Guillory and Gasaway 1978, Becker 1983, Emery 1985, Burr and Page 1986, Mulvey 1990, Fago 1992); and Wyoming (Courtenay et al. 1984, 1991, Stone 1995). Also in Puerto Rico (Erdman 1984)."

"In Ontario, Canada, a single grass carp was collected from Lake Erie in 1985, west of Point Pelee Point National Park (Crossman et al. 1987); a total of four fish were taken at two locations in Lake Huron, off Point Edward in 1989 and near Sarnia in 1998, 2001, and 2008 (Royal Ontario Museum); and reported from Lake Ontario, but no specimens (Cudmore-Vokey et al. 2000). In 2013, two fish were taken from the Grand River, a tributary of Lake Erie near Dunnville, Ontario (B. Cudmore, OMNR, pers. comm.). Both Grand River fish proved to be sterile triploids when analyzed."

Means of Introductions in the United States

From Nico et al. (2014):

"Both authorized and unauthorized stockings of grass carp have taken place for biological control of vegetation. This species was first imported to the United States in 1963 to aquaculture facilities in Auburn, Alabama, and Stuttgart, Arkansas. The Auburn stock came from Taiwan, and the Arkansas stock was imported from Malaysia (Courtenay et al. 1984). The first release of this species into open waters took place at Stuttgart, Arkansas, when fish escaped the Fish Farming Experimental Station (Courtenay et al. 1984). However, many of the early stockings in Arkansas were in lakes or reservoirs open to stream systems, and by the early 1970s there were many reports of grass carp captured in the Missouri and Mississippi rivers (Pflieger 1975, 1997). During the past few decades, the species has spread rapidly as a result of widely scattered research projects, stockings by federal, state, and local government agencies, legal and illegal interstate transport and release by individuals and private groups, escapes from farm ponds and aquaculture facilities; and natural dispersal from introduction sites (e.g., Pflieger 1975; Lee et al. 1980 et seq.; Dill and Cordone 1997). Some of the agencies that have stocked grass carp in the past include the Arkansas Game and Fish Commission, the Tennessee Valley Authority, the U.S. Fish and Wildlife Service, the Delaware Division of Fish and Wildlife, the Florida Game and Fresh Water Fish Commission, the Iowa Conservation Commission, the New Mexico Department of Fish and Game, and the Texas Parks and Wildlife Department. The species also has been stocked by private individuals and organizations. In some cases, grass carp have escaped from stocked waterbodies and appeared in nearby waterbodies. Stocking of grass carp as a biological control against nuisance aquatic plants in ponds and lakes continues. For instance, Pflieger (1997) stated that thousands of grass carp are reared and sold by fish farmers in Missouri and Arkansas."

Remarks

From Nico et al. (2014):

"In an article by Sandy Bauers of the Philadelphia Inquirer (1995), it is reported that Philadelphia is taking precautions to ensure that the [released] carp are sterile. The fish are sterilized by subjecting fertilized eggs to extreme heat or extreme cold. The result is a triploid fish rather than a normal diploid fish. Before the fish are shipped off to be stocked in area lakes, each specimen undergoes two mandatory blood tests by the US Fish and Wildlife Service and the diploid fish are removed."

"DeVaney et al. (2009) performed ecological niche modeling to examine the invasion potential for grass carp and three other invasive cyprinids (common carp *Cyprinus carpio*, black carp *Mylopharyngodon piceus*, and tench *Tinca tinca*). The majority of the areas where grass carp have been collected, stocked, or have become established had a high predicted ecological suitability for this species."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2011):

"Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Osteichthyes
Class Actinopterygii
Subclass Neopterygii – neopterygians
Infraclass Teleostei
Superorder Ostariophysi
Order Cypriniformes
Superfamily Cyprinoidea
Family Cyprinidae
Genus Ctenopharyngodon
Species Ctenopharyngodon idella (Valenciennes in Cuvier and Valenciennes, 1844)

Taxonomic Status: Valid."

Size, Weight, and Age Range

From Shireman and Smith (1983):

"Maturity: Lm ?, range 58 - 79.2 cm; Max length : 150 cm TL male/unsexed; (Billard 1997); common length : 10.7 cm SL male/unsexed; (Nichols 1943); max. published weight: 45.0 kg (Skelton 1993); max. reported age: 21 years."

Environment

From Shireman and Smith (1983):

"Freshwater; demersal; potamodromous (Riede 2004); depth range 0 - 30 m (Shao and Lim 1991)."

Climate/Range

From Shireman and Smith (1983):

"Subtropical; ? - 35°C (Laird and Page 1996); 65°N - 25°N."

Distribution Outside the United States

Native

From Shireman and Smith (1983):

"Asia: China to eastern Siberia (Amur River system, Berg 1964). Widely transported around the world (Skelton 1993)."

Introduced

From Shireman and Smith (1983):

"Persists only in Europe by stocking (Kottelat and Freyhof 2007). Introductions often brought with it the parasitic tapeworm *Bothriocephalus opsarichthydis* (synonym of *B. acheilognathi*) (Kottelat and Whitten 1996). Several countries report adverse ecological impact after introduction."

This species has been reported as introduced in Italy, Taiwan, Albania, Azerbaijan, Armenia, Brunei, Bulgaria, Colombia, Croatia, Guam, Hong Kong, Jamaica, Jordan, Kyrgyzstan, Latvia, Mongolia, Moldova, Papua New Guinea, Reunion, Saudi Arabia, Ukraine, Uruguay, Singapore, Afghanistan, Finland, Kazakhstan, Turkmenistan, UK, Estonia, Zambia, Malaysia, Japan, Indonesia, Thailand, Sri Lanka, USSR (Russian Fed), France, Viet Nam, India, Romania, Czech Republic, Slovakia, Uzbekistan, Hungary, Korea, Serbia (Formerly Yugoslavia), Germany, Pakistan, Philippines, Poland, Belarus, Denmark, Israel, Jordan River, Mexico, Nepal, Cuba, Iran, Netherlands, New Zealand, Belgium, Myanmar, Brazil, Fiji, Iraq, United Arab Emirates, Hawaii, Bangladesh, Kenya, Egypt, Sweden, Nigeria, Puerto Rico, Switzerland, Argentina, Austria, Ethiopia, Mauritius, South Africa, Sudan, Costa Rica, Honduras, Malawi, Cyprus, Laos, Panama, Haiti, Côte d'Ivoire, Lesotho, Peru, Rwanda, Uganda, Angola, Greece, Morocco, Bolivia, Cambodia, Dominican Republic, Tunisia, Tanzania, Guyana, Bhutan, Oubéira lake and dams, Turkey, Burundi, Canada, Guatemala, Mozambique and Zimbabwe (FAO 1997a).

Means of Introduction Outside the United States

From Shireman and Smith (1983):

Reasons given for introduction of the species include angling, aquaculture, weed control, research, fisheries, phyto-zooplankton control and unknown. Species is reported to be established and having negative impacts on native species in some locations where introduced (FAO 1997a).

Short description

From Shireman and Smith (1983):

"Dorsal spines (total): 3; Dorsal soft rays (total): 7-8; Anal spines: 3; Anal soft rays: 7 - 11. No barbels. Snout very short, its length less than or equal to eye diameter. Postorbital length more than half head length (Keith and Allardi 2001). 18 soft rays for caudal fin (Eccles 1992). Diagnosed from rather similar species *Mylopharyngodon piceus* by having the following characters: body olive to brassy green above, silvery white to yellow below; body cylindrical; pharyngeal teeth laterally compressed, serrated, with a groove along grinding surface, usually in two rows, 2,5-4,2 (Kottelat and Freyhof 2007)."

Biology

From Shireman and Smith (1983):

"Adults occur in lakes, ponds, pools and backwaters of large rivers (Page and Burr 1991), preferring large, slow-flowing or standing water bodies with vegetation. Tolerant of a wide range of temperatures from 0° to 38°C, and salinities to as much as 10 ppt and oxygen levels down to 0.5 ppm. Feed on higher aquatic plants and submerged grasses; takes also detritus, insects and other invertebrates… Spawn on riverbeds with very strong current (Billard 1997)."

Human uses

From Shireman and Smith (1983):

"Fisheries: minor commercial; aquaculture: commercial; gamefish: yes."

"One of the world's most important aquaculture species and also used for weed control in rivers, fish ponds and reservoirs (Frimodt 1995)."

"Utilized also fresh and eaten steamed, pan-fried, broiled and baked (Frimodt 1995)."

Diseases

From Shireman and Smith (1983):

Water mold Disease (l.), Fungal diseases; Fish louse Infestation 1, Parasitic infestations; Columnaris Disease (l.), Bacterial diseases; Water mold Disease (e.), Fungal diseases; Columnaris Disease (e.), Bacterial diseases; Columnaris Disease (m.), Bacterial diseases; SVC, Viral diseases; Myxidium Infection 1, Parasitic infestations; Trichodina Infection 1, Parasitic infestations; Trichodina Infection 2, Parasitic infestations; Trichodina Infection 3, Parasitic infestations; Tripartiella Infestation, Parasitic infestations; Bothriocephalus Infestation 2, Parasitic infestations; Trichodina Infection 5, Parasitic infestations; Trichodina Infection 5, Parasitic infestations; Myxobolus Infection 1, Parasitic infestations; Fish louse Infestation 1, Parasitic infestations; Dactylogyrus Gill Flukes Disease, Parasitic infestations; Trichodinosis, Parasitic infestations; Sporozoa-infection (Myxobolus sp.), Parasitic infestations; Anchorworm Disease (Lernaea sp.), Parasitic infestations; Piscinoodinium Infection, Parasitic infestations; Capillaria Infestation, Parasitic infestations; Gonad Nematodosis Disease, Parasitic infestations;

Spiroxys Infestation, Parasitic infestations; Grass Carp Picornavirus, Viral diseases; Grass Carp Haemorrhagic Disease Reovirus, Viral diseases; Unclassifed Grass Carp Virus, Viral diseases; Sanguinicola Infection 1, Parasitic infestations and Anchor worm Disease, Parasitic infestations. **SVC Viral Diseases** is OIE-reportable.

Threat to humans

Potential pest.

3 Impacts of Introductions

From Shireman and Smith (1983):

"Considered as a pest in most countries because of the damages made to submerged vegetation (Kottelat 2001)."

From Nico et al. (2014):

"Various authors (e.g., Shireman and Smith 1983, Chilton and Muoneke 1992, Bain 1993) have reviewed the literature on grass carp; most also discuss actual and potential impacts caused by the species' introduction. Shireman and Smith (1983) concluded that the effects of grass carp introduction on a water body are complex and apparently depend on the stocking rate, macrophyte abundance, and community structure of the ecosystem. They indicated that numerous contradictory results are reported in the literature concerning grass carp interaction with other species. Negative effects involving grass carp reported in the literature and summarized by these authors included interspecific competition for food with invertebrates (e.g., crayfish) and other fishes, significant changes in the composition of macrophyte, phytoplankton, and invertebrate communities, interference with the reproduction of other fishes, decreases in refugia for other fishes, and so on. In their overview, Chilton and Muoneke (1992) reported that grass carp seem to affect other animal species by modifying preferred habitat, an indirect effect. However, they also indicated that grass carp may directly influence other animals through either predation or competition when plant food is scarce. In his review, Bain (1993) stated that grass carp have significantly altered the food web and trophic structure of aquatic systems by inducing changes in plant, invertebrate, and fish communities. He indicated that effects are largely secondary consequences of decreases in the density and composition of aquatic plant communities. Organisms requiring limnetic habitats and food webs based on phytoplankton tend to benefit from the presence of grass carp. On the other hand, Bain reported that declines have occurred in the diversity and density of organisms that require structured littoral habitats and food chains based on plant detritus, macrophytes, and attached algae. Removal of vegetation can have negative effects on native fish, such as elimination of food sources, shelter, and spawning substrates (Taylor et al. 1984). Hubert (1994) cited a study that found vegetation removal by grass carp lead to better growth of rainbow trout due to increases in phytoplankton and zooplankton production, but it also lead to higher predation on rainbow trout by cormorants *Phalacrocorax auritus* due to lack of cover, and changes in diet, densities, and growth of native fishes. Although grass carp are often used to control selected aquatic weeds, these fish sometimes feed on preferred rather than on target plant species (Taylor et al. 1984). Increases in phytoplankton populations [are] a secondary effect of grass carp presence. A single grass carp can digest only about half of the approximately 45 kg of plant material that it consumes each day. The remaining material is expelled into the water, enriching it and promoting algal blooms (Rose 1972). These blooms can reduce water clarity and decrease oxygen levels (Bain 1993). In addition to the above, grass carp may carry several parasites and diseases known to be transmissible or potentially transmissible to native fishes. For instance, it is believed that grass carp imported from China were the source of introduction of the Asian tapeworm *Bothriocephalus opsarichthydis* (Hoffman and Schubert 1984, Ganzhorn et al. 1992). As such, the species may have been responsible indirectly for the infection of the endangered woundfin *Plagopterus argentissimus* (by way of the red shiner *Cyprinella lutrensis*) (Moyle 1993)."

GISD (2014):

"Grass carp (*Ctenopharyngodon idella*) are voracious feeders. Many of their introductions have been for the control of aquatic vegetation. However, they are known to completely eliminate aquatic plants in introduced habitats altering trophic structure and inflicting widespread detrimental effects on ecosystems. They may also feed selectively on softer plants thereby enhancing development of tougher plants. Grass carp remove macrophyte cover, eliminate spawning substrate, disturb sediment and muddy waters, reduce water quality, increase nutrients in waters accelerating eutrophication, decrease oxygen levels, and promote alagal bloom. They compete with native invertebrates and fish for food and other important resources. Reported impacts on native fishes include the reduction of bluegill, sunfish, smelt, bully, and pike populations. Grass carp are believed to impact waterfowl by reducing aquatic vegetation, an essential food source. Significant declines of gadwall (*Anas stepera*), American wigeon (*Anas americana*), and American coot (*Fulica americana*) have been reported following grass carp introductions. They carry diseases and parasites which are transmittable to other fish and are believed to be the main vector for Asian tapeworms (*Bothriocephalus opsarichthydis*) known to infect several fishes in Canada including common carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*), fathead minnow (*Pimephales promelas*), channel catfish (*Ictalurus punctatus*). One record cites grass carp as the vector for the infection of endangered woundfin (*Plagopterus argentissimus*) (Standish and Wattendorf 1987, Jordan 2003, Jacobson and Kartalia 1994, Nico et al. 2006, GSMFC 2005, McKnight and Hepp 1995, Mitchell 1986, Elvira 2001)."

"Location Specific Impacts:
Belarus
Modification of natural benthic communities: *Ctenopharyngodon idella* is thought to cause pronounced successions of vegetation in canals by consuming large amounts of macrophytes (FishBase 2008)."

"Greece
Ecosystem change: *Ctenopharyngodon idella* has altered trophic structure and food chains of introduced habitats of Greece (Leonardos 2008).
Reduction in native biodiversity: The introduction of *Ctenopharyngodon idella* to Lake Pamvotis resulted in a significant reduction of submerged macrophytes and the near [disappearance] of endemic Epirus minnow (*Phoxinellus epiroticus*), the native Epirus barbell (*Barbus albanicus*)

and and *Squalius pamvoticus* by means of habitat reduction, egg predation, and reduction of habitat (Leonardos 2008)."

"New Zealand
Reduction in native biodiversity: Stocking of *Ctenopharyngodon idella* in Parkinsons Lake, New Zealand resulted in reduced the size and abundance of native New Zealand smelt (*Retropinna retropinna*) and the New Zealand common bully (*Gobiomorphus cotidianus*) (Mitchell 1986)."

"Texas (United States (USA))
Reduction in native biodiversity: A decrease in sunfish accompanied the removal of aquatic vegetation by *Ctenopharyngodon idella* (Jacobson 1994)."

From Santiago (2014):

"*C. idella*, the grass carp, is considered as a potential pest. In the USA, it has been recorded in 45 states and is known to have established populations in at least eight states in the Mississippi River Basin (Ramussen 2000a, Nico and Fuller 2005, Nico et al. 2010). The rapid spread of the species is attributed to: widely scattered research projects, stockings by different government agencies (federal, state, and local), interstate transport and release (legal and illegal) by individuals and private groups, and more importantly, escapes from farm ponds and aquaculture facilities and escapes from stocked waterbodies to nearby waterbodies.
Although stocking of grass carp as a biological control against nuisance aquatic plants in ponds and lakes continues, the importation, stocking, sale and possession of grass carp are controlled in some US states by state code and permit programme (Ramussen 2000a, b). Moreover, a vigorous campaign against the spread of non-native, invasive fish species that includes grass carp is being coordinated by the US Aquatic Nuisance Species Task Force."

"Overstocking of grass carp [causes] a large influx of nutrients derived from the carp faeces and a fast or substantial decrease of macrophytes in lakes and ponds. Adverse effects of overstocking of grass carp in various countries as reviewed by Shireman and Smith (1983) include:

- phytoplankton blooms (USSR, Yugoslavia, Romania, India)
- a decrease in the invertebrate numbers and diversity (USSR and USA)
- disruption of macroinvertebrate food base and consequent reduction in centrarchid biomass in a reservoir (USA)
- reduction in the spawning sites for other fishes such as the largemouth bass and bluegill, *Lepomis macrochirus* (USA)
- and prevention of spawning by pike, *Esox lucius*, and perch, *Lucioperca fluviatilis*, in small Russian lakes."

"Changes in water quality in lakes as a result of drastic reduction of macrophytes by the grass carp include a decrease in dissolved oxygen and increase in carbon dioxide levels in a lake in Yugoslavia, and increase in Kjeldahl nitrogen and significant decrease in pH in a lake in Florida (USA) (Shireman and Smith 1983). On the other hand, the presence of grass carp improved oxygen levels in a reservoir (USSR) since grass carp drastically reduced the macrophytes that normally cause low dissolved oxygen during seasonal die-offs and decomposition."

"A more exhaustive study on the environmental impact of grass carp as a weed control agent in nutrient enriched waters was done in New Zealand. After 15 years of research, the conclusions were:

- the grass carp were environmentally safe
- damage to native and introduced fisheries would be minimal
- the likelihood of breeding was low
- harmful effect of weed removal by fish would be much less than by herbicide or mechanical means (FAO 1997b, FishBase 2004).

However, only sterile fish are released for weed control (De Zylva 1996)."

"Contradictory results have been reported concerning grass carp interaction with other species since many factors influence the effects of grass carp introduction in a body of water. In his review, Petr (2000) reported that removal of aquatic vegetation (*Hydrilla verticillata*, *Myriophyllum spicatum* and *Ceratophyllum demersum*) by grass carp in a lake system (Lake Conroe) result in the decline of some fish species (e.g., small phytophilic, *Lepomis spp*., bluegill, *Lepomis machrochirus*, and crappie, *Pomoxis spp*.) and a nearly fivefold increase in the density of threadfin shad, *Dorosoma petenense*. The sportfish community changed from the original largemouth bass-crappie-hybrid striped bass (*Morone chrysops* x *M. saxatilis*) fishery to a channel catfish-white bass-hybrid striped bass-largemouth bass-black crappie, after vegetation removal. The littoral fish community also shifted from a sunfish and shad community to one that included large numbers of cyprinids, inland silversides, *Menidia beryllina*, and channel catfish. In many other lakes, there was no consistent trend on the effect of aquatic macrophyte removal in that some grass carp lakes supported excellent fish populations and some did not."

"Grass carp affects other fish species by interfering with their reproduction, broadening or narrowing their food base, and decreasing their refugia (Shireman and Smith 1983). Overfeeding of grass carp on aquatic vegetation affects habitats for migrating and wintering waterfowl because the native aquatic plants preferred by grass carp are also important food for the waterfowl and habitat for invertebrate food items (Welcomme 1988, Petr, 2000). Grass carp has also been reported to compete for plant food with crayfish, *Procambarus clarkii*, in small ponds leading to a decrease in crayfish production."

"Accidental introduction of the intestinal parasite, *Bothriocephalus acheilognathi* (=gowkongensis), is associated with the introduction of grass carp (FishBase 2004) from the Far East and has caused extensive losses in common carp culture in Europe (Shireman and Smith 1983). In the USA, various tests have shown that the golden shiner virus that causes mortalities in golden shiners, *Notemigonus crysoleucas*, is the same as the grass carp reovirus which must have been imported into the country along with the introduction of grass carp (McEntire et al. 2003)."

"Vegetation removal by grass carp has been reported to improve growth of rainbow trout due to increases in phytoplankton and zooplankton production (a secondary effect of the presence of grass carp), but it also led to higher predation on rainbow trout by cormorants, *Phalacrocorax auritus*, due to lack of cover, and changes in diet, densities, and growth of native fishes (Nico and Fuller 2005)."

4 Global Distribution

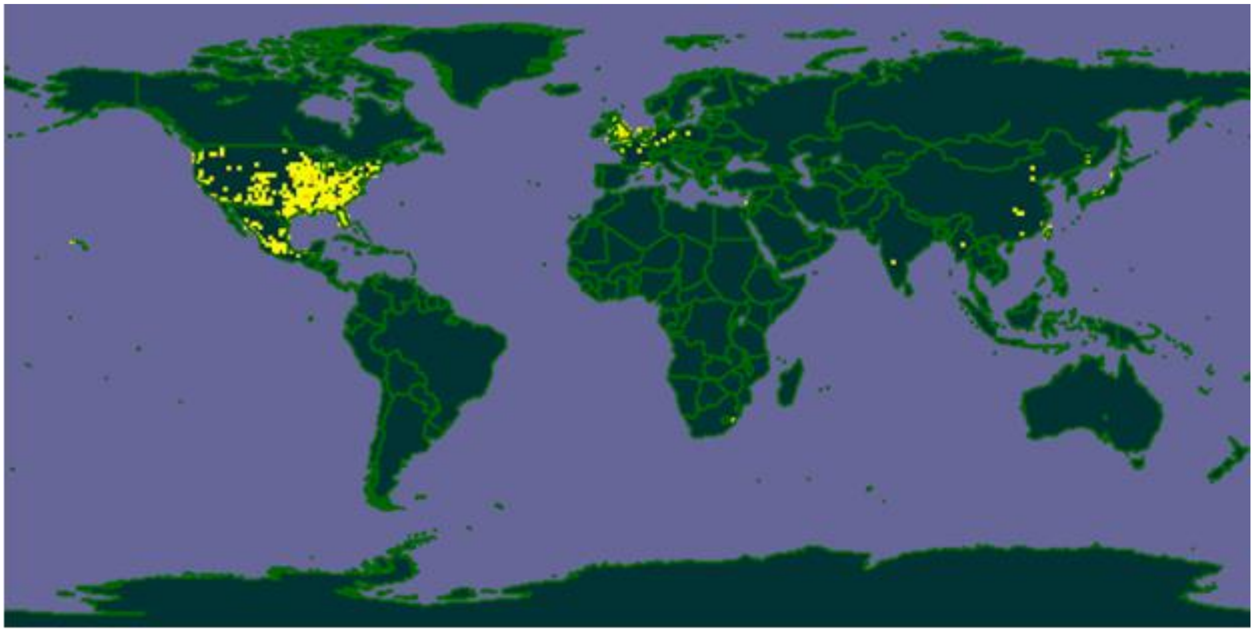

Figure 1. Global distribution of *Ctenopharyngodon idella*. Map from GBIF (2011).

5 Distribution within the United States

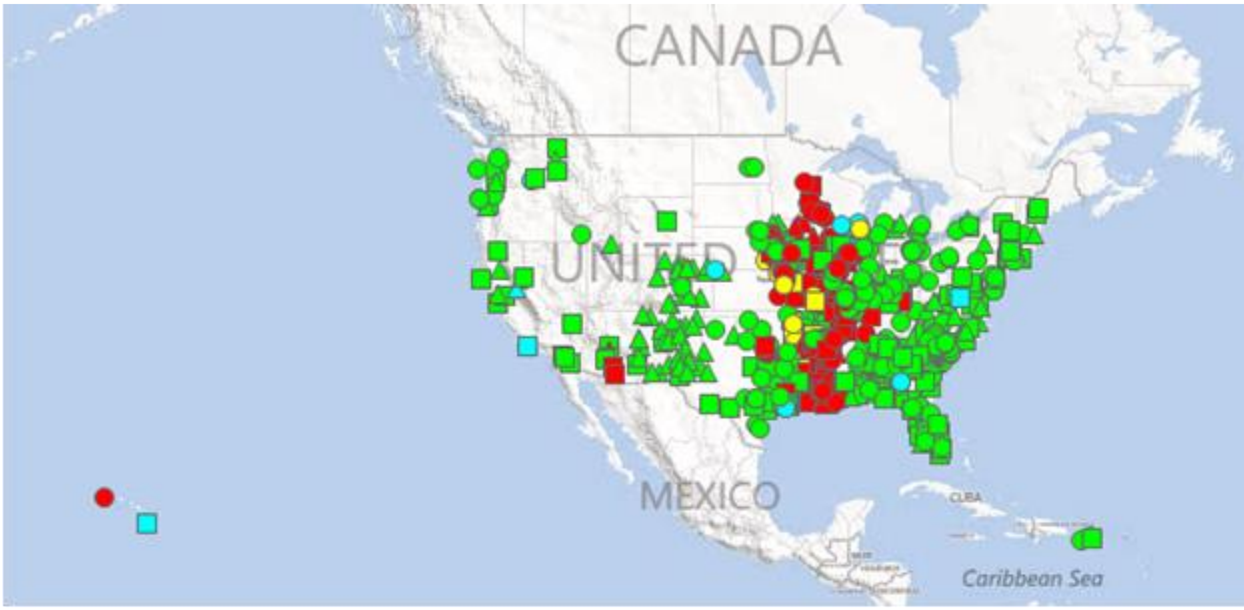

Figure 2. Distribution of *Ctenopharyngodon idella* in the US. Map from Nico et al. (2014).

6 CLIMATCH

Summary of Climate Matching Analysis

The climate match (Australian Bureau of Rural Sciences 2008; 16 climate variables; Euclidean Distance) was high for all states in the Eastern and Southern U.S. and moderate for the Mountain West and Coastal West U.S. Climate 6 match indicated that the contiguous U.S. has a high climate match. The range for a high climate match is 0.103 and greater; climate match of *Ctenopharyngodon idella* is 0.802.

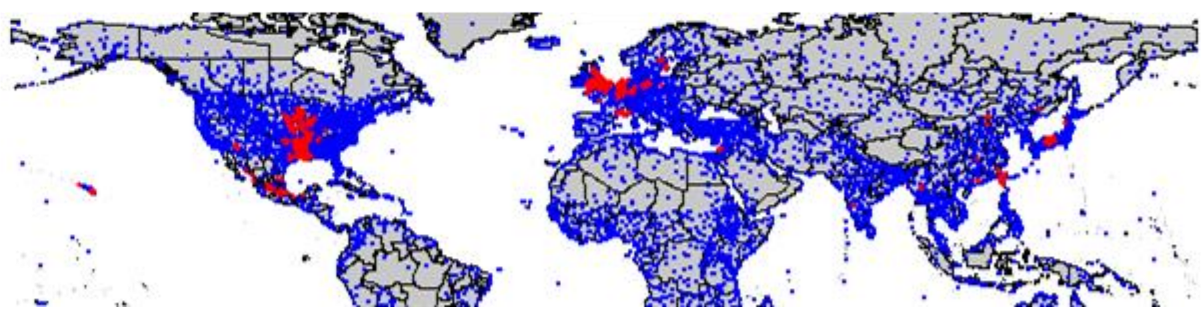

Figure 3. CLIMATCH (Australian Bureau of Rural Sciences 2008) source map showing weather stations selected as source locations (red) and non-source locations (blue) for *Ctenopharyngodon idella* climate matching. Source locations from GBIF (2011) and Nico et al. (2014).

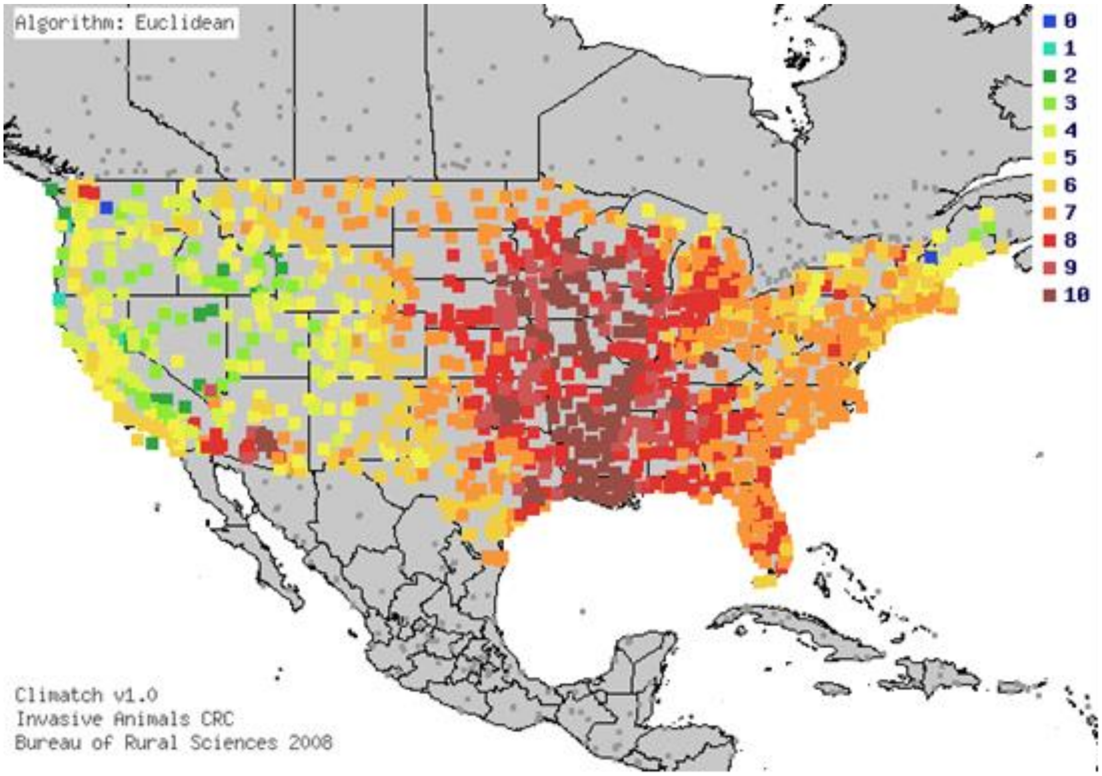

Figure 4. Map of CLIMATCH (Australian Bureau of Rural Sciences 2008) climate matches for *Ctenopharyngodon idella* in the contiguous United States based on source locations reported by GBIF (2011) and Nico et al. (2014). 0= Lowest match, 10=Highest match.

Table 1. CLIMATCH (Australian Bureau of Rural Sciences 2008) climate match scores.

CLIMATCH Score	0	1	2	3	4	5	6	7	8	9	10
Count	2	3	18	58	101	208	381	501	380	116	206
Climate 6 Proportion =		0.802									

7 Certainty of Assessment

Information on the biology, distribution, and impacts of *Ctenopharyngodon idella* is readily available. Negative impacts from introductions of this species are adequately documented in the scientific literature. No further information is needed to evaluate the negative impacts the species is having where introduced. Certainty of this assessment is high.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Ctenopharyngodon idella is a freshwater fish native to the Amur River system in Asia. This species consumes aquatic plants and invertebrates. It is commonly used for aquaculture and for weed control. *Ctenopharyngodon idella* has established in the United States and Europe, where it causes a variety of impacts. This species removes aquatic vegetation, causing changes in the food web and in the physical habitat of an ecosystem. This species promotes algal blooms and might compete with native species for food. *Ctenopharyngodon idella* also carries several diseases. Climate match with the contiguous U.S. is high, especially in the Mississippi River basin. Overall risk for this species is high.

Assessment Elements

- **History of Invasiveness (Sec. 3):** High
- **Climate Match (Sec.6):** High
- **Certainty of Assessment (Sec. 7):** High
- **Remarks/Important additional information** Host of 30 diseases/parasites some of which are OIE-reportable; listed as a potential pest.
- **Overall Risk Assessment Category: High**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

Australian Bureau of Rural Sciences. 2008. CLIMATCH. Available: http://data.daff.gov.au:8080/Climatch/climatch.jsp. (February 2011).

Froese, R., and D. Pauly. Editors. 2010. FishBase. Available: http://www.fishbase.us/summary/Ctenopharyngodon-idella.html. (February 2011).

Global Biodiversity Information Facility (GBIF). 2011. Available: http://www.gbif.org/species/2362030. (February 2011).

Global Invasive Species Database (GISD) 2014. *Ctenopharyngodon idella*. Available from: http://www.issg.org/database/species/ecology.asp?si=369&fr=1&sts=&lang=EN. (July 2014).

ITIS. 2011. *Ctenopharyngodon idella*. Integrated Taxonomic Information System. Available: http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=163537. (April 2011).

Nico, L.G., P.L. Fuller, P.J. Schofield, M.E. Neilson, and A.J. Benson. 2014. *Ctenopharyngodon idella*. USGS Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=514.

Santiago, C. 2014. *Ctenopharyngodon idealla* (Grass Carp). CAB International, Wallingford, United Kingdom. Available: http://www.cabi.org/isc/datasheet/16772. (July 2014).

Shireman, J.V., and C.R. Smith. 1983. Synopsis of biological data on the grass carp, *Ctenopharyngodon idella* (Cuvier and Valenciennes, 1884). FAO Fisheries Synopsis No.135.

10 References Quoted But Not Accessed

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

Anonymous. 1977. Grass carp problems. SFI Bulletin 288: 5.

Anonymous. 1994. Water body records. Texas Parks & Wildlife News 1994 (February 25): 1-19.

Bain, M. 1993. Assessing impacts of introduced aquatic species: grass carp in large systems. Environmental Management 17: 211-224.

Bain, M.B., D.H. Webb, M.D.Tangedal, and L.N. Mangum. 1990. Movements and habitat use by grass carp in a large mainstream reservoir. Transactions of the American Fisheries Society 119: 553-561.

Bauers, S. 1995. Debate on Fish that Can't Scale Back. The Philadelphia Inquirer, City & Region Section, Philadelphia, Pennsylvania.

Becker, G.C. 1983. Fishes of Wisconsin. University of Madison Press, Madison, Wisconsin.

Berg, L.S. 1964. Freshwater fishes of the U.S.S.R. and adjacent countries. volume 2, 4th edition. Israel Program for Scientific Translations Ltd, Jerusalem. (Russian version published 1949).

Beshears, E. 2004. High water may have sent grass carp fleeing. The Charlotte Observer, Charlotte, North Carolina.

Beshears, E. 2005. Fish brought to feed on unwelcome weed. The Charlotte Observer, Charlotte, North Carolina.

Billard, R. 1997. Les poissons d'eau douce des rivières de France. Identification, inventaire et répartition des 83 espèces. Delachaux & Niestlé, Lausanne.

Blodgett. 1993. ***[Source did not provide reference].***

Boschung, H.T. 1992. Catalog of freshwater and marine fishes of Alabama. Bulletin of the Alabama Museum of Natural History 14: 1-266.

Brown and Coon. 1991. ***[Source did not provide reference].***

Buchanan, T.M. 1973. Key to the Fishes of Arkansas. Arkansas Game and Fish Commission.

Burkhead, N.M., and J.D. Williams. 1991. An intergeneric hybrid of a native minnow, the golden shiner, and an exotic minnow, the rudd. Transactions of the American Fisheries Society 120: 781-795.

Burkhead, N.M., S.J. Walsh, B.J. Freeman, and J.D. Williams. 1997. Status and restoration of the Etowah River, an imperiled southern Appalachian ecosystem. Pages 375-444 *in* G.W. Benz, and D.E. Collins, editors. Aquatic fauna in perile: the southeastern perspective. Southeast Aquatic Research Institute, Lenz Design & Communications. Decatur, Georgia.

Burr, B.M., and L.M. Page. 1986. Zoogeography of the fishes of the lower Ohio-upper Mississippi basin. Pages 287-324 *in* C.H. Hocutt, and E.O. Wiley, editors. The zoogeography of North American freshwater fishes. John Wiley and Sons, New York, New York.

Burr, B.M., and M.L. Warren, Jr. 1986. A distributional atlas of Kentucky fishes. Scientific and Technical Series No. 4. Kentucky State Nature Preserves Commission, Frankfort, Kentucky.

Burr, B.M., D.J. Eisenhour, K.M. Cook, C.A. Taylor, G.L. Seegert, R.W. Sauer, and E.R. Atwood. 1996. Nonnative fishes in Illinois waters: what do the records reveal? Transactions of the Illinois State Academy of Science 89(1/2): 73-91.

Carp Task Force. 1989. Report to the Louisiana Legislature, March, 1989. US Fish and Wildlife Service.

Cashner and Matthews. 1988. ***[Source did not provide reference].***

Charlotte Harbor NEP. 2004. ***[Source did not provide reference].***

Chilton, III, E.W., and M.I. Muoneke. 1992. Biology and management of grass carp (*Ctenopharyngodon idella*, Cyprinidae) for vegetation control: a North American perspective. Reviews in Fish Biology and Fisheries 2: 283-320.

Clugston. 1990. ***[Source did not provide reference].***

Colle, D.E., R.L. Cailteaux, and J.V. Shireman. 1989. Distribution of Florida largemouth bass in a lake after elimination of all submersed aquatic vegetation. North American Journal of Fisheries Management 9: 213-218.

Conner, J.V., and R.D. Suttkus. 1986. Zoogeography of freshwater fishes of the western Gulf Slope of North America. Pages 413-456 *in* C.H. Hocutt, and E.O. Wiley, editors. The Zoogeography of North American Freshwater Fishes. John Wiley and Sons, New York, New York.

Conner, J.V., R.P. Gallagher, and M.F. Chatry. 1980. Larval evidence for natural reproduction of the grass carp (*Ctenopharyngodon idella*) in the lower Mississippi River. *In* L.A. Fuiman, editor. Proceedings of the Fourth Annual Larval Fish Conference. FWS/OBS-80/43. United States Fish and Wildlife Service, Biological Services Program, National Power Plant Team, Ann Arbor, Michigan.

Courtenay. 1993. ***[Source did not provide reference].***

Courtenay, W. R., Jr., D. A. Hensley, J. N. Taylor, and J. A. McCann. 1984. Distribution of exotic fishes in the continental United States. Pages 41-77 *in* W. R. Courtenay, Jr., and J. R. Stauffer, Jr., editors. Distribution, biology and management of exotic fishes. Johns Hopkins University Press, Baltimore, Maryland.

Courtenay, W.R., Jr., D.P. Jennings, and J.D. Williams. 1991. Appendix 2: Exotic fishes. Pages 97-107 *in* C.R. Robins, R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott, editors. Common names and scientific names of fishes from the United States and Canada. 5th edition. American Fisheries Society. Bethesda, Maryland.

Courtenay and Williams. 1992. ***[Source did not provide reference].***

Cowley, D.E., and J.E. Sublette. 1987. Distribution of fishes in the Black River drainage, Eddy County, New Mexico. Southwestern Naturalist 32(2): 213-221.

Cross, F.B., and J.T. Collins. 1995. Fishes in Kansas. University of Kansas Natural History Museum. Lawrence, Kansas.

Crossman, E.J., S.J. Nepszy, and P. Krause. 1987. The first record of grass carp, *Ctenopharyngodon idella*, in Canadian waters. Canadian Field-Naturalist 101(4): 584-586.

Cudmore-Vokey, B., and E.J. Crossman. 2000. Checklists of the fish fauna of the Laurentian Great Lakes and their connecting channels. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2550. Fisheries and Oceans Canada, Burlington, Ontario.

Deacon, J.E., and J.E. Williams. 1984. Annotated list of the fishes of Nevada. Proceedings of the Biological Society of Washington 97(1): 103-118.

DeVaney, S.C., K.M. McNyset, J.B. Williams, A.T. Peterson, and E.O. Wiley. 2009. A tale of four "carp": invasion potential and ecological niche modeling. PLoS ONE 4(5): e5451.

De Zylva, R. 1996. NZ approves diploid grass carp for weed control. Fish Farming International, 23(10).

Dill, W.A., and A.J. Cordone. 1997. History and status of introduced fishes in California, 1871-1996. California Department of Fish and Game Fish Bulletin, volume 178.

Eccles, D.H. 1992. FAO species identification sheets for fishery purposes. Field guide to the freshwater fishes of Tanzania. Prepared and published with the support of the United Nations Development Programme (project URT/87/016). FAO, Rome.

Emery, L. 1985. Review of fish introduced into the Great Lakes, 1819-1974. Great Lakes Fishery Commission Technical Report. 45: 1-31.

Elder and Murphy. 1997. ***[Source did not provide reference].***

Elvira, B. 2001. Identification of non-native freshwater fishes established in Europe and assessment of their potential threats to the biological diversity. Convention on the Conservation of European Wildlife and Natural Habitats. Standing Committee 21st meeting Strasbourg, 26-30 November 2001.

Erdman, D.S. 1984. Exotic fishes in Puerto Rico. Pages 162-176 *in* W.R. Courtenay, Jr., and J.R. Stauffer, Jr, editors. Distribution, biology, and management of exotic fishes. John Hopkins University Press. Baltimore, Maryland.

Etnier, D.A., and W.C. Starnes. 1993. The fishes of Tenneessee. University of Tennessee Press, Knoxville, Tennessee.

Fago, D. 1992. Distribution and relative abundance of fishes in Wisconsin. VIII. Summary Report. Technical Bulletin, Department of Natural Resources, Madison, Wisconsin.

FishBase. 2004. Entry for *Ctenopharyngodon idella*. Main ref.: Shireman JV, Smith CD, 1983. Synopsis of biological data on the grass carp, *Ctenopharyngodon idella* (Cuvier and Valenciennes, 1884). FAO Fisheries Synopsis No.135.

FishBase, 2008. *Ctenopharyngodon idella* Grass carp. Available: http://www.fishbase.org/Summary/speciesSummary.php?ID=79&genusname=Ctenopharyngodon&speciesname=idella. (March 2008).

Florida Game and Fresh Water Fish Commission. 1989. Aquatic Plant Management Utilizing triploid grass carp. 1 July 1988- 30 June 1989.

Florida Game and Fresh Water Fish Commission. 1994. ***[Source did not provide reference].***

FAO. 1997a. FAO Database on Introduced Aquatic Species. FAO Database on Introduced Aquatic Species, FAO, Rome.

FAO. 1997b. Aquaculture production statistics 1986-1995. FAO Fisheries Circular 815, Revision 9.

Foltz and Kirk. 1994. ***[Source did not provide reference].***

Frimodt, C. 1995. Multilingual illustrated guide to the world's commercial warmwater fish. Fishing News Books, Osney Mead, Oxford, England.

Ganzhorn, J., J.S. Rohovec, and J.L. Fryer. 1992. Dissemination of microbial pathogens through introductions and transfers of finfish. Pages 175-192 *in* A. Rosenfield, and R. Mann, editors. Dispersal of living organisms into aquatic ecosystems. Maryland Sea Grant. College Park, Maryland.

Guillory, V., and R.D. Gasaway. 1978. Zoogeography of the grass carp in the United States. Transactions of the American Fisheries Society 107: 105-112.

Gulf States Marine Fisheries Commission (GSMFC). 2005. *Ctenopharyngodon idella* (Valenciennes, 1844) Available from: http://nis.gsmfc.org/nis_factsheet.php?toc_id=182. (March 2008).

Harlan, J.R., E.B. Speaker, and J. Mayhew. 1987. Iowa fish and fishing. Iowa Department of Natural Resources.

Hartel, K. 1992. Non-native fishes known from Massachusetts freshwaters. Occasional Reports of the MCZ Fish Department 2: 1-9.

Hartel et al. 1996. ***[Source did not provide reference].***

Hatch, J.T, and K. Schmidt. 2002. Fishes of Minnesota: Distribution in 8 Major Drainage Basins. Available: http://www.gen.umn.edu/faculty_staff/hatch/fishes/distribution_table.html.

Hill, J., and C. Cichra. 2005. Eradication of a reproducing population of convict cichlids, *Cichlasoma nigrofasciatum* (Cichlidae) in North-Central Florida. Florida Scientist 68(2): 65-74.

Hoffman, F.L., and G. Schubert. 1984. Some parasites of exotic fishes. Pages 233-261 *in* W.R. Courtenay, Jr., and J.R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. The Johns Hopkins University Press, Baltimore, Maryland.

Howells, R.G. 1992. Annotated list of introduced non-native fishes, mollusks, crustaceans and aquatic plants in Texas waters. Texas Parks and Wildlife Department, Management Data Series 78, Austin, Texas.

Howells. 1993. ***[Source did not provide reference].***

Howells, R. 1999. Guide to Identification of Harmful and Potentially Harmful Fishes, Shellfishes, and Aquatic Plants Prohibited in Texas. Texas Parks and Wildlife Department, Austin.

Hubert, W. 1994. Exotic fishes. Pages 158-174 *in* T.L. Parish, and S.H. Anderson, editors. Exotic species manual. Wyoming Game and Fish Department. Laramie, Wyoming.

Idaho Department of Fish and Game. 1990. ***[Source did not provide reference].***

Illinois Natural History Survey. 2004. Illinois Natural History Survey Fish Collection Database Search Results.

Jacobson. 1994. ***[Source did not provide reference].***

Jacobson, T.P., and S.D. Kartalia. 1994. Ecological risk assessment of the effects of grass carp on submerged aquatic vegetation in Chesapeake Bay. Toward a Sustainable Coastal Watershed: The Chesapeake Experiment. Proceedings of a Conference 1-3 June 1994. Norfolk, Virginia Chesapeake Research Consortium Publication No. 149.

Jenkins, R.E., and N.M. Burkhead. 1994. Freshwater Fishes of Virginia. American Fisheries Society, Bethesda, Maryland.

Jordan, M. 2003. Review- Grass carp: are they a safe biological control agent for nuisance aquatic vegetation? Available from: www.invasive.org/gist/moredocs/cteide02.rtf. (January 2010).

Keith, P., and J. Allardi (coords.). 2001. Atlas des poissons d'eau douce de France. Muséum national d'Histoire naturelle, Paris. Patrimoines naturels 47: 1-387.

Kirk et al. 1994. ***[Source did not provide reference].***

Kottelat, M. 2001. Fishes of Laos. WHT Publications Ltd., Colombo 5, Sri Lanka.

Kottelat, M., and T. Whitten. 1996. Freshwater biodiversity in Asia, with special reference to fish. World Bank Technical Paper 343.

Kottelat, M., and J. Freyhof. 2007. Handbook of European freshwater fishes. Publications Kottelat, Cornol, Switzerland.

Kulla. 2004. ***[Source did not provide reference].***

Laird, C.A., and L.M. Page. 1996. Non-native fishes inhabiting the streams and lakes of Illinois. Illinois Natural History Survey Bulletin 35(1): 1-51.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh, North Carolina.

Leonardos, I.D., I. Kagalou, M. Tsoumani, and P.S. Economidis. 2008. Fish fauna in a Protected Greek lake: biodiversity, introduced fish species over a 80-year period and their impacts on the ecosystem. Ecology of Freshwater Fish 17(1): 165-173.

Maciolek, J.A. 1984. Exotic fishes in Hawaii and other islands of Oceania. Pages 131-161 *in* W.R. Courtenay, Jr., and J.R. Stauffer, Jr, editors. Distribution, biology, and management of exotic fishes. John Hopkins University Press. Baltimore, Maryland.

McEntire, M.E., L.R. Iwanowicz, and A.E. Goodwin. 2003. Molecular, physical, and clinical evidence that golden shiner virus and grass carp reovirus are variants of the same virus. Journal of Aquatic Animal Health 15: 257-263.

McKnight, K.S., and G.R. Hepp. 1995. Potential Effect of Grass Carp Herbivory on Waterfowl Foods. The Journal of Wildlife Management 59(4): 720-727.

Menhinick, E. F. 1991. The freshwater fishes of North Carolina. North Carolina Wildlife Resources Commission, North Carolina.

Mettee, M.F., P.E. O'Neil, and J.M. Pierson. 1996. Fishes of Alabama and the Mobile Basin. Oxmoor House, Inc., Birmingham, Alabama.

Minckley, W.L. 1973. Fishes of Arizona. Arizona Fish and Game Department, Phoenix, Arizona.

Mississippi Museum of Natural Science. 2011. Mississippi Museum of Natural Science - Ichthyology Collection. Mississippi Museum of Natural Science, Mississippi.

Mitchell, C.P. 1986. Effects of introduced grass carp on populations of two species of small native fishes in a small lake. New Zealand Journal of Marine and Freshwater Research 20: 219-230.

Moyle, P.B. 1993. Assessing effects on ecosystem function, structure and resilience. Performance Standards Workshop. August 18-20, 1993. Workshop for Performance Standards for safely conducting research w/ genetically modified fish & shellfish in Agricultural Biotechnology Research Advisory Committee, Working Group on Aquatic Biotechnology and Environmental Safety. University of Minnesota, Minneapolis, Minnesota.

Mulvey, M. 1990. Voracious carp seen in area waterways. Milwaukee Sentinel, Milwaukee, Wisconsin.

Nichols, J.T. 1943. The freshwater fishes of China. Natural history of Central Asia: Volume IX. The American Museum of Natural History, New York, New York.

Nico, L.G. 2005. Changes in the fish fauna of the Kissimmee River Basin, peninsular Florida: nonnative additions. Pages 523-556 *in* J.N. Rinne, R.M. Hughes, and B. Calamusso, editors. Historical changes in large river fish assemblages of the Americas. American Fisheries Society Symposium 45. American Fisheries Society, Bethesda, Maryland.

Nico, L., and P. Fuller. 2005. *Ctenopharyngodon idella* (Valenciennes, 1844). Nonindigenous Aquatic Species Database. Gainesville, Florida. Available: http://flgvwdmz014.er.usgs.gov/queries/FactSheet.asp?speciesID=514. (February 2005).

Nico, L.G., P.L. Fuller, and P.J. Schofield. 2006. *Ctenopharyngodon idella*. USGS Nonindigenous Aquatic Species Database, Gainesville, Florida. Available from: http://nas.er.usgs.gov/queries/FactSheet.asp?speciesID=514. (March 2008).

Nico, L.G., P.L. Fuller, and P.J. Schofield. 2010. *Ctenopharyngodon idella*. USGS Nonindigenous Aquatic Species Database. Gainesville, Florida. http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=514.

Owen, J.B., D.S. Elsen, and G.W. Russell. 1981. Distribution of Fishes in North and South Dakota Basins Affected by the Garrison Diversion Unit. Fisheries Research Unit, University of North Dakota, Grand Forks, North Dakota.

Page, L.M., and B.M. Burr. 1991. A field guide to freshwater fishes of North America north of Mexico. The Peterson Guide Series, vol. 42. Houghton Mifflin Company, Boston, Massachusetts.

Pauley, G.B., G.L. Thomas, S.A. Bonar, J.D. Frodge, D.A. Marino, S.L. Thiesfeld, S. Vecht, K.L. Bowers, and H. Sehgal. 1994. An overview of the use and efficacy of triploid grass carp *Ctenopharyngodon idella* as a biological control of aquatic macrophytes in Oregon and Washington Lakes. *In* Proceedings of the Grass Carp Symposium March 7-9, 1994, Gainesville, FL. US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Pearson and Krumholz. 1984. ***[Source did not provide reference].***

Petr, T. 2000. Interactions between fish and aquatic macrophytes in inland waters a review. FAO Fisheries Technical Paper No. 396.

Pflieger, W.L. 1975. The Fishes of Missouri. Missouri Department of Conservation, Missouri.

Pflieger. 1978. ***[Source did not provide reference].***

Pflieger, W. 1997. The fishes of Missouri. Missouri Department of Environmental Conservation, Jefferson City, Missouri.

Phillips, G.L., W.D. Schmid, and J.C. Underhill. 1982. Fishes of the Minnesota region. University of Minnesota Press, Minneapolis, Minnesota.

Pigg, J., R. Gibbs, and J. Stahl. 1992. Distribution records for three new introduced species of the ichthyofauna of Oklahoma waters. Proceedings of the Oklahoma Academy of Science 72: 1-2.

Power, G.J., and F. Ryckman. 1998. North Dakota Fisheries Investigations: status of North Dakota's fishes. Available: http://www.npwrc.usgs.gov/resource/fish/fshries/index.htm.

Raasch, M.S., and V.L. Altemus, Sr. 1991. Delaware's freshwater and brackish water fishes - a popular account. Delaware State College Center for the Study of Del-Mar-Va Habitats and the Society of Natural History of Delaware, Dover, Delaware.

Raibley, P.T., D. Blodgett, and R.E. Sparks. 1995. Evidence of grass carp (*Ctenopharyngodon idella*) reproduction in the Illinois and Upper Mississippi Rivers. Journal of Freshwater Ecology 10(1): 65-74.

Rasmussen, J.L. 1998. Aquatic nuisance species of the Mississippi River basin. 60th Midwest Fish and Wildlife Conference, Aquatic Nuisance Species Symposium, Dec. 7, 1998, Cincinnati, Ohio.

Ramussen, J. 2000a. Summary (by state) of Asian Carp distribution in the Mississippi River basin. Mississippi Interstate Cooperative Resource Association. Available: http://www.aux.cerc.cr.usgs.gov/MICRA/AsianCarpSurvey.pdf. (October 2004).

Ramussen, J. 2000b. Summary of permit authority and prohibited species by state with special emphasis on Asian carp. Mississippi Interstate Cooperative Resource Association. Available: http://www.aux.cerc.cr.usgs.gov/MICRA/ansregs.pdf. (October 2004).

Red River Authority of Texas. 2001. Red and Canadian Basins Fish Inventory: Grayson County. Red River Authority of Texas.

Riede, K. 2004. Global register of migratory species - from global to regional scales. Final Report of the R&D-Projekt 808 05 081. Federal Agency for Nature Conservation, Bonn, Germany.

Roesler, R. 2003. Freed pets taking over. The Spokesman-Review. Spokane, Washington.

Rohde et al. 1994. ***[Source did not provide reference].***

Rose, S. 1972. What about the white amur? A superfish or a super curse? The Florida Naturalist 1972: 156-157.

Ross, S.T. 2001. The inland fishes of Mississippi. University Press of Mississippi, Jackson, Mississippi.

Ryon, M.G., and J.M. Loar. 1988. Checklist of fishes on the Department of Energy Oak Ridge Reservation. Journal of the Tennessee Academy of Sciences 63: 97-102.

Schmidt, R.E. 1986. Zoogeography of the northern Appalachians. Pages 137-160 *in* C.H. Hocutt, and E.O. Wiley, editors. The zoogeography of North American freshwater fishes. John Wiley and Sons, New York, New York.

Schramm, H.L., Jr., and M.C. Basler. 2004. Evaluation of capture methods and distribution of black carp in Mississippi. Mississippi State University, Mississippi.

Shafland, P.L. 1996. Exotic fishes of Florida – 1994. Reviews in Fisheries Science 4(2): 101-122.

Shao, K.T., and P.L. Lim. 1991. Fishes of freshwater and estuary. Encyclopedia of field guide in Taiwan, volume 31. Recreation Press, Co., Ltd., Taipei.

Sigler, W.F., and J.W. Sigler. 1996. Fishes of Utah. University of Utah Press, Salt Lake City, Utah.

Simon, T.P., J.O. Whitaker, Jr., J.S. Castrale, and S.A. Minton. 1992. Checklist of the vertebrates of Indiana. Proceedings of the Indiana Academy of Science 101: 95-126.

Skelton, P.H. 1993. A complete guide to the freshwater fishes of southern Africa. Southern Book Publishers.

Smith, C.L. 1985. The inland fishes of New York State. New York State Department of Environmental Conservation, Albany, New York.

Smith, P.W. 1979. The fishes of Illinois. University of Illinois Press, Urbana, Illinois.

Starnes, W.C., J. Odenkirk, and M.J. Ashton. 2011. Update and analysis of fish occurrences in the lower Potomac River drainage in the vicinity of Plummers Island, Maryland—Contribution XXXI to the natural history of Plummers Island, Maryland. Proceedings of the Biological Society of Washington 124(4): 280-309.

Standish, A.K., Jr., and R.J. Wattendorf. 1987. Triploid Grass Carp: Status and Management Implications. Fisheries 12(4): 20-24.

Stone, M.D. 1995. Fish stocking programs in Wyoming: a balanced perspective. Pages 47-51 *in* H.L. Schramm, Jr., and R.G. Piper, eds. Uses and effects of cultured fishes in aquatic ecosystems. American Fisheries Society Symposium 15. American Fisheries Society. Bethesda, Maryland.

Sublette, J.E., M.D. Hatch, and M. Sublette. 1990. The fishes of New Mexico. University of New Mexico Press, Albuquerque, New Mexico.

Taylor, J.N., W.R. Courtenay, Jr., and J.A. McCann. 1984. Known impact of exotic fishes in the continental United States. Pages 322-373 *in* W.R. Courtenay, Jr., and J.R. Stauffer, Jr, editors. Distribution, biology, and management of exotic fishes. John Hopkins University Press, Baltimore, Maryland.

Texas Parks and Wildlife Department. 2001. Fish Records: Water Body - All Tackle. Texas Parks and Wildlife Department, Texas.

Thiery. 1990. ***[Source did not provide reference].***

Tilmant, J.T. 1999. Management of nonindigenous aquatic fish in the U.S. National Park System. Paper presented at the 129th Annual Meeting of The American Fisheries Society, Charlotte, North Carolina, September 1, 1999: 50.

Trimm, D.L., G. Guillen, C.T. Menn, and G.C. Matlock. 1989. The occurrence of grass carp in Texas water. The Texas Journal of Science 41(4): 413-417.

Tseng, N. 2002. UF imports fish to clean Lake Alice. Gainesville Sun, Gainesville, Florida.

Tucker. 1979. ***[Source did not provide reference].***

U.S. Fish and Wildlife Service. 2005. National Wildlife Refuge System Invasive Species. Available: http://www.nwrinvasives.com/index.asp (2006).

Vinyard, G.L. 2001. Fish Species Recorded from Nevada. Biological Resources Research Center 5. Available: http://www.brrc.unr.edu/data/animal/vertebrates/fishlist.htm.

Waldrip. 1992. ***[Source did not provide reference].***

Waldrip, L. 1993. 13 State record fish certified. Texas Parks and Wildlife Department, Texas.

Walters, D.M. 1997. The distribution, status, and ecology of the fishes of the Conasauga River system. Unpublished M.S. thesis. University of Georgia, Athens, Georgia.

Webb et al. 1994. ***[Source did not provide reference].***

Welcomme, R.L. 1988. International introductions of inland aquatic species. FAO Fisheries Technical Paper No. 294.

Whitworth, W.R. 1996. Freshwater fishes of Connecticut. Bulletin 114. State Geological and Natural History Survey of Connecticut, Department of Environmental Protection, Hartford, Connecticut.

Woodling, J. 1985. Colorado's Little Fish: a guide to the minnows and other lesser known fishes in the state of Colorado. Colorado Division of Wildlife, Denver, Colorado.

Yoon, C.K. 2003. Texans call in a monster fish to tame a monster weed. New York Times, New York.

Young, B.A., T.L. Welker, M.L. Wildhaber, C.R. Berry, and D. Scarnecchia, editors. 1997. Population structure and habitat use of benthic fishes along the Missouri and lower Yellowstone rivers. US Army Corps of Engineers and the US Bureau of Reclamation. Available: http://www.cerc.usgs.gov/pubs/benfish/pdfdocs/benth97.pdf.

Zimpfer et al. 1987. ***[Source did not provide reference].***